

4/PRTS

09/381526  
420 Rec CT/PTO 20 SEP 1999

Substitute Specification 41-303-3

METHOD FOR ANCHORING JOINING ELEMENTS IN MATERIAL HAVING  
PORES OR CAVITIES AND JOINING ELEMENTS FOR ANCHORING

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FIELD OF THE INVENTION

This invention relates to a method of anchoring joining elements in a material having pores or cavities, particularly in wood or wood-like materials (e.g., chip-boards). The invention also relates to joining elements for use in the method. The joining elements anchored according to the method of the invention are more particularly used for producing constructions comprising different parts or for attaching fittings.

BACKGROUND OF THE INVENTION

According to the prior art, parts made from wood or woody materials are interconnected, e.g., using joining elements in the form of nails or screws which are driven through one of the parts to be joined into the other part to be joined. Screws and nails are generally made from metal and have a head in a surface area of one of the parts to be joined and are at least frictionally or positively anchored in another of the parts to be joined. These pin-like joining elements constitute in wooden structures metallic, often corrosive, foreign bodies which can be prejudicial to working after the joining of the parts and which represent heat transfer bridges in the finished structures.

It is also known to join parts made from fibrous materials, including wood and wood-like materials, to parts made from thermoplastics. The thermoplastic is plasticized at its surface facing the fibrous material part and the two surfaces are pressed onto one another. The plastic is thereby applied in plasticized form to the surface of the fibrous material or it is plasticized in the final position, e.g., by ultrasonic excitation. In all of these methods, a joint is formed at the interface between the plastic and the fibrous material in the sense of a microscopic interlocking in that the plasticized plastics material is pressed into surface irregularities of the fibrous material. Such methods are, e.g., described in FR-2 455 502, FR 1 495 999, DE-38 28 340 or EP-269476. According to WO-96/01 377, the plastics part can also be a dowel, which joins together two wooden parts. The same principle forms the basis for known methods for joining parts made from wood or wood-like materials, in which between the parts to be joined is placed a layer of a thermoplastics material, e.g., a paint layer, and the parts are then pressed together and subjected to ultrasonic action (JP 52 127 937, WO 96/01377).

In all the aforementioned methods, synthetic material and fibrous material are joined together by surface adhesion resulting from microscopic interlocking and this occurs in the same way in conventional bonding or adhesion processes. The above methods have many of the same disadvantages as bonding methods, particularly their sensitivity to moisture and thermal stresses in which the two joined-together surfaces expand to varying degrees and considerable shear forces arise which weaken or even destroy the joint.

#### SUMMARY OF THE INVENTION

An object of the present invention is to provide a method for anchoring joining elements, e.g., joining pins, in parts made

from a material having pores or cavities, particularly in parts made from wood or wood-like materials, this method being based on the aforementioned methods for joining plastic/synthetic material and wooden parts, but in which the disadvantages thereof are at least reduced, i.e., in particular provides anchors, which are more stable under thermal and/or moisture stresses and loads. The method is simple, but still adaptable in specific ways to joining elements with different functions and to different material types. The method is also performable with known means and tools and at a limited cost.

According to the method of the invention, an anchoring plasticized synthetic material is not merely pressed into surface irregularities as in the known methods, but instead into pores or cavities within the part in which the joining element is to be anchored, so that a macroscopic anchor is formed. This macroscopic anchor is based on the penetration of the plasticized synthetic material into microscopic pores of the material and to the formation of a type of composite comprising the original porous material and the synthetic material which has penetrated it or to macroscopic interlocking, which results from the fact that the plasticized synthetic material is pressed into macroscopic cavities.

According to the method of the invention in which the joining element is to be anchored, an opening with a closed end, e.g., a bore (blind hole) is formed and then the joining element is positioned in the bore, the joining element being wholly or partly made from a thermoplastic material.

The shapes of the bore and the joining element are so matched to one another that the joining element, without force expenditure, can be introduced into the bore up to a first position and that, if it is driven with the aid of a pressing force parallel to the bore axis from the first position toward the closed end of the bore into a second, final position,

pressure builds up at at least one predetermined anchoring point between the joining element and the bore wall, but no pressure arises at other points.

5 Simultaneously with the pressing in of the joining element from its first to its second position in the bore, or immediately prior thereto, energy is supplied to the joining element in such a way that the plastics material is locally plasticized at the  
10 aforementioned, predetermined anchoring points where the pressure is concentrated. This planned, local plasticizing can, e.g., be achieved by providing at least one of the following characteristics:

- the joining element is entirely made from a thermoplastic material or at least in areas of the predetermined anchoring points has at least surface areas made from a thermoplastic material and the joining element is subjected to ultrasonic or some other appropriate vibration action for supplying energy, so that at the pressure concentration points (predetermined anchoring points) the greatest friction and therefore the maximum heat is produced and consequently the thermoplastic material is locally plasticized (related to joining methods such as ultrasonic, friction, vibration or orbital welding);
- the joining element, in areas of the predetermined anchoring points, has at least surface areas of a thermoplastic material which are plasticizable at a lower temperature than the remaining materials of the joining element and in that the joining element is heated by heat supply;
- the joining element, in areas of the predetermined

anchoring points, has at least surface areas of a thermoplastic material, in which are incorporated metal particles and so that the joining element can be inductively heated.

5 In the inside of the joining element which, in the closed bore, is directed toward the closed end of the bore, the joining element has at least one first, predetermined anchoring point. On its outside end, i.e., on the end projecting from the bore or positioned in the bore opening, the joining element has a  
10 thickening serving as a head or a means for attaching a further part or has further anchoring points spaced toward the outside from the first anchoring point. It is also conceivable to have pin-like joining elements with several predetermined anchoring points.

15 While the joining element is pressed in the second, final position in the bore and energy is simultaneously supplied thereto, at the predetermined anchoring points where a high pressure occurs between the joining element and the bore wall, the joining element material is plasticized and as a result of the pressure at these points is pressed into the bore wall or  
20 into pores or cavities in the material which is adjacent to the bore, whereas it remains unchanged at other points.

To be sure that the plasticized synthetic material is pressed by the pressure produced at the anchoring points into the  
25 bore wall, the bore wall must be porous or have openings or cavities, or the bore wall must be created in such a way that, as a result of the pressure, formed pores or cavities are produced into which the plasticized material can be pressed. Porous materials suitable for anchors according to the method of the  
30 invention are in particular wood or wood-like materials, but also sandstone, ceramic materials, burnt brick or concrete, etc. Cavities suitable for producing anchors according to the

invention open substantially transversely to the bore axis and are in particular found in lightweight structural components.

The attainable depth of the anchoring of a synthetic material in a porous material is dependent on its structure (e.g., for wood on the density of the wood fibers), but also on the pressure applied and the locally available plasticized material quantity. As will be shown hereinafter, in solid wood, e.g., anchoring depths of 1 to 4 cm are readily attainable.

The desirable depth of the anchor of the synthetic material in a porous material is dependent on the loadability of the material and can be controlled by the quantity of material to be pressed in and/or by the applied pressing force level. The shape of the anchor can be substantially controlled by suitable matching of the bore shape and the joining element shape. Thus, using the method according to the invention it is possible to produce anchors which are specifically adapted to the character of the material (e.g., wood type, orientation of the graining or density gradient relative to the orientation of the bore, etc.) in which the anchoring is to be accomplished and to the function and loading to be absorbed by the joining element.

The most advantageous bore and joining element shapes for a specific application, as well as the pressing force level and the quantity of energy to be supplied to the joining element are to be established experimentally in each specific case.

## BRIEF DESCRIPTION OF THE DRAWINGS

The inventive method for anchoring joining elements in a part made from a porous material, particularly wood or a wood-like material, or a material having suitable cavities and different types of joining elements, is described in greater detail hereinafter with reference to the attached drawings, wherein:

Fig. 1 is a diagram showing successive steps in one embodiment of a method for anchoring a joining pin with a head in one wooden part for joining two wooden parts;

Fig. 2 is a diagram showing successive steps in another embodiment of a method for anchoring a joining pin in two wooden parts to be joined;

Figs. 3, 4 and 5 are diagrams showing steps of forming three embodiments of the anchoring point in areas of the closed bore end;

Fig. 6 is a side elevation of a fitting, which is attached to a wooden part using a plurality of joining pins anchored in the wooden part.

Fig. 7 is a sectional side elevation of a method for anchoring a joining element which has an internal thread for attaching further parts; and

Fig. 8 is a sectional side elevation of an anchor according to the invention anchored in a lightweight component with cavities.

In all of the drawings, the joining elements, bores and anchors are shown in section along the bore axis.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig. 1 shows a first embodiment of the inventive method which involves anchoring a pin-like joining element 3.1 with a head 32 in a first, wooden part 1 for joining first part 1 to a second part 2.1, which is, e.g., also made from wood.

In the vicinity of its inner end, joining pin 3.1 has a predetermined, first anchoring point 31 and at its outer end has a head 32. Bore 4.1 passes entirely through part 2.1 and has, in part 1, a closed end 41, the total length of bore 4.1 being less  
 5 deep than the length of joining pin 3.1. At the open end of bore 4.1 is, e.g., a widened depression for countersinking head 32. The cross-section of bore 4.1 is so matched to the cross-section of the joining pin 1 that, without force expenditure, the pin can be introduced into the bore up to closed end 41 thereof. This is  
 10 the first position of joining pin 3.1 in bore 4.1.

From the first position, joining pin 3.1 is pressed further into bore 4.1 with a pressing force  $F$  oriented substantially parallel to the bore axis. The only point at which the pressing force  $F$  gives rise to pressure between joining pin 3.1 and the wall of the bore 4.1 is the area of closed bore end 41. If, in the above-described manner, by supplying energy to the joining pin it is ensured that during pressing in the material of the joining pin is only plasticized at this point, only at this point is there anchoring 10 of the joining pin in the part 1 to be  
 15 joined.

In the drawing, anchoring location 10 is shown as a synthetic material area, but in fact is constituted by an intimate mixture of wood fibers and synthetic material, which can be likened to a composite material and which can, e.g., be of  
 20 pinewood, whose graining is oriented parallel to the bore axis where it has a depth of up to 2 cm.

The length of joining pin 3.1, the depth of bore 4.1, the magnitude of force  $F$  and the quantity of energy to be supplied are so matched to one another that the anchor fulfils the desired  
 25 strength conditions and that the two parts are firmly fixed together between joining pin head 32 and anchoring point 10.

Pin 3.1 of Fig. 1 is anchored in part 1 by the anchoring point 10, which is only possible in a part made from a porous



material, particularly wood or a wood-like material, or, if the bore wall material has suitable cavities in the vicinity of the anchoring point or if the pressure exerted on the joining pin produces such openings in the bore wall.

5        Part 2.1 can also be made from wood or some other, non-porous material (metal, plastic). As shown in Fig. 1, the head 32 can be a component of the joining pin. However, the head can also be placed on the joining pin after producing the anchor, e.g., can be screwed into a thread provided in the joining pin.  
10       The head 32 can be in any random form and can, e.g., also represent a fitting with a specific function.

20       An advantage of joining two parts in the manner shown in Fig. 1 compared with other joining methods, in which plasticized materials are used as joining materials, is that in all cases it is possible to prevent plasticized material being pressed into the gap between the parts 1 and 2.1 to be joined, resulting in the pressing apart thereof. This is prevented by the feature that, in the region of such a gap, no pressure is built up and the material of the joining pin is not plasticized in that region.

25       ~~sub E1~~ If the energy to be supplied to the joining pin is supplied in the form of ultrasonic waves, in the manner shown, joining pin 3.1 must be made from a thermoplastic material in the area of its inner end to be positioned, as shown on the closed bore end 41. The remainder of the pin can be made from the same material or a different material.

30       If the energy to be supplied to joining pin 3.1 is supplied in the form of heat, in the vicinity of the anchoring point it is constituted by a plastics material which is plasticizable at a lower temperature than the material from which the joining pin is made in other areas. It is also conceivable in such a case for the joining pin to have a "core" of a heat conducting material, e.g., metal, by means of which core the heat to be supplied to

the joining pin can be conducted toward the anchoring point.

If the energy to be supplied to the joining pin is supplied inductively, the thermoplastic material of the predetermined anchoring point 31 contains incorporated metal particles.

Fig. 2 shows a further embodiment of the inventive method using an anchor of a pin-like joining element (joining pin 3.2) in two parts 1 and 2.2 to be joined together and which are, e.g., of wood, joining pin 3.2 being anchored in both parts 1 and 2.2 (anchoring points 10 and 20).

Like joining pin 3.1 of Fig. 1, joining pin 3.2 has a predetermined, first anchoring point 31 at its inner end to be inserted in the bore. It also has a predetermined, second anchoring point 33, which is in the form of a step-like cross-sectional reduction and on the pin is positioned where it is located in the second part 2.2 to be joined.

Bore 4.2 has a cross-sectional reduction 42 corresponding to the cross-sectional reduction on joining pin 3.2 and on it rests the joining pin in its first position. If joining pin 3.2 is pressed by pressing force  $F$  more deeply into the bore 4.2, pressure builds up not only in the vicinity of closed end 41 of the bore 4.2, but also in the area of cross-sectional reduction 42, is pressed through the plastics material plasticized at this point into the wall of the bore 4.2 and consequently forms a second anchor point 20.

Bores 4.1 and 4.2 of Figs. 1 and 2 advantageously have a circular cross-section. Joining pins 3.1 and 3.2 can also be circular. However, they can also have some other cross-section fitting into the corresponding bore. For example, in the vicinity of its smaller cross-section, joining pin 3.2 can be circular and in the area of its larger cross-section can have an angular cross-section (e.g. square) with only the areas of the edges resting on the step 42.

In both Figs. 1 and 2 closed end 41 of the bore is shown

flat and the joining pin in its first position rests with a flat face in the bore. With such a shaping of the bore and joining pin, on pressing in the pin, a substantially uniform pressure builds up over the entire face. The plasticized material is  
 5 mainly driven into the wood parallel to the longitudinal axis of the joining pin, so that the cross-section of anchoring point 10 is only slightly larger than the cross-section of the joining pin.

Such a construction of the predetermined, first anchoring  
 10 point is advantageous for applications in which, in the vicinity of the first anchor 10, the wood grain is oriented parallel to the bore axis and the wood of part 1 splits in the case of a limited displacement. Roughly the same effect is obtainable with a pin end tapered to a point, which in its first position rests  
 15 on a roughly identically tapering bore end.

Figs 3 to 5 show further embodiments advantageous for specific applications of predetermined, first anchoring points 31 on, e.g., pin-like joining elements 3 and cooperating, closed  
 20 ends 41 of bores 4, which particularly in the case of ultrasonic application, leads to different anchor points 10.

Fig. 3 shows two embodiments of inner ends of a joining pin 3 which is placed in a closed end of a bore 4. In both cases, the pin end is pointed, specifically more sharply than the bore end. As a result the pressure arising when pressing the joining pin 3  
 25 into the bore 4 is centrally concentrated, so that the material is, to an even greater extent, pressed parallel to the pin axis into the part 1, so that also here the resulting anchor point 10 extends more in the axial direction than at right angles thereto. The strength of such an anchor is more particularly due to an  
 30 enlargement of the shear-loaded surfaces in the wood.

Fig. 4 shows one end of a pin 3 having a concave shape. When pressing this pin into a bore with a flat or pointed, closed end, the pressure mainly builds up at radial positions, which gives

rise to an anchor 10, which extends to a greater extent transversely to the pin axis. Such an anchoring is more particularly suitable for a part 1 where the grain is at right angles to the pin axis, or for an anchor in a chipboard, whose surface is at right angles to the pin axis. The strength of such an anchor results more particularly from the interlocking obtained between the wooden part and the joining pin.

Fig. 5 shows another embodiment of the predetermined, first anchor point 31 on a joining pin 3 and a corresponding bore end 41. It is a first anchor point having substantially the same construction as the second anchoring point of Fig. 2. Bore 4 has a step-like cross-sectional reduction 43, on which is mounted the pin in its first position. When this joining pin is pressed into the bore, more particularly a pressure is built up radially in the vicinity of the bore end and the plasticized material is pressed into the wood more particularly transversely to the pin axis.

Fig. 6 shows a part 5 made from a random material, which is fixed to a part 1 using pin-like joining elements 3 which are anchored in part 1 which is, e.g., made from wood and in accordance with the method of the invention. Part 5 is a fitting (e.g. a hinge part), e.g., made from plastic. Two joining pins 3 are formed onto part 5 or are joined thereto in some other appropriate way and are driven in the described way into bores of part 1 and anchored therein. Here again, as mentioned in conjunction with Fig. 1 concerning a joining pin head, part 5 can have a random shape and, even after producing the anchor, can be appropriately mounted on joining pin or pins 3.

Fig. 7 shows the production of a connection of a wooden part 1 with a fitting part 6, e.g., made from metal, by means of an inventive anchor of a joining element 3.3 in part 1 and the attachment of fitting part 6 to the anchored joining element 3.3. Joining element 3.3 has a two-step, first anchoring point 31 and

is introduced into a bore 4.3 with a step-like, narrowing base. On pressing the joining element into the bore and during the simultaneous plasticizing of the anchoring point 31, bore 4.3 and joining element 3.3 act as explained in conjunction with Fig. 4.

5 A mating "two-step" anchor 10 is formed.

Joining element 3.3 of Fig. 7 has at its outside, facing the predetermined anchoring point, as the means for fixing a further part, an internal thread 34, into which is screwed fitting part 6 after anchoring the joining element 3.3 in part 1.

10 Fig. 8 shows the result of a further embodiment of the inventive method, namely an anchor of a joining element 3.4 in a part 1, which is a lightweight constructional component with cavities 11. The closed bore necessary for the method according to the invention and into which is introduced the joining element 3.4. is in this case a through-bore 4.4 through one of the outer layers 1.1 of part 1. This through-bore 4.4 is closed by a further element, e.g., by an inner layer 1.2 or optionally by the facing, outer layer 1.3, in such a way that between through-bore 4.4 and the element closing it opens a cavity area 11.1 extending substantially at right angles to the bore axis or is produced by the pressure of joining element 3.4 on the bore-closing element, e.g., by a corresponding deformation of inner layer 1.2.

Joining element 3.4 is inserted in bore 4.4 and is positioned by the bore-closing element (e.g. inner layer 1.2).

25 Joining element 3.4 is then pressed against the bore-closing element and simultaneously the plastics material is plasticized in the area of this element and is pressed into the cavity area 11.1, existing or produced between the outer layer 1.1 and the bore-closing element, so that a macroscopic anchor 10 is

30 obtained.

As has been stated, the method according to Fig. 8 is particularly suitable for light-weight construction applications where, in place of solid material, use is made of thin, board-

like material carried by a support structure (indicated by the two laths 20). Outer layers 1.1 and 1.3 are, e.g., thin, solid wood boards or coated chipboards. The element closing bore 4.4 can, e.g., be a plastic or metal inner layer 1.2 extending from a lath 20 to a neighboring lath 20 or over the entire surface of the first layer, or can be a differently shaped element locally and specifically integrated for this purpose into cavity 11.

Joining element 3.4 according to Fig. 8 is, e.g., suitable for attaching fittings to lightweight structural components.

Thermoplastic materials for use in joining elements advantageously have a high mechanical strength, particularly a high tensile strength and a high modulus of elasticity. Polyamides, polycarbonates or polyester carbonates are particularly suitable. For increasing the strength, the plastics material of a joining element can, e.g., also contain glass or carbon fibers. Further thermoplastics materials suitable for use as joining elements are acrylonitrile butadiene-styrene, styrene-acrylonitrile, polymethylmethacrylate, polyvinyl chloride, polyethylene, polypropylene and polystyrene.

A joining pin for joining two wooden parts, as shown in Fig. 2, e.g., has the form shown in Fig. 2 and is made entirely from acrylonitrile butadiene-styrene. It has a smaller portion with a circular cross-section of a diameter of 8 mm and a larger portion having a circular cross-section with a diameter of 10 mm. It is 60 mm long and is centrally provided with the cross-sectional reduction. The mating bore is 40 mm deep and has the step positioned to correspond to the cross-sectional reduction of the pin at a height of 30 mm. The pin is inserted in the bore and is pressed into it for 5 sec. with a pressing force of 2000 N and ultrasonic excitation with an amplitude of approximately 44  $\mu\text{m}$ . Upon completion of the assembly, the outer pin end is flush with the wood surface.

METHOD FOR ANCHORING JOINING ELEMENTS IN A MATERIAL HAVING PORES OR CAVITIES, AS WELL AS JOINING ELEMENTS FOR ANCHORING

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The invention relates to a method according to the preamble of claim 1. The method is used for anchoring joining elements in a material having pores or cavities, particularly in wood or woodlike materials (e.g. chipboards). The invention also relates to joining elements for use in the method. The joining elements anchored according to the method of the invention are more particularly used for producing constructions constituted by different parts or for fixing fittings.

According to the prior art parts made from wood or woody materials are interconnected e.g. using joining elements in the form of nails or screws, in that they are driven through one of the parts to be joined into the other part to be joined. Screws and nails are generally made from metal and have in surface areas of one of the parts to be joined a head and are at least frictionally or positively anchored in another of the parts to be joined. These pin-like joining elements constitute in wooden structures metallic, often corrosive foreign bodies, which can be prejudicial to working after the joining of the parts and which represent heat transfer bridges in the finished structures.

It is also known to join parts made from fibrous materials, including wood and woodlike materials, to parts made from thermoplastics, in that the thermoplastic is plasticized at its surface facing the fibrous material part and the two surfaces are pressed onto one another. The plastic is thereby applied in plasticized form to the surface of the fibrous material or it is plasticized in the final position, e.g. by ultrasonic excitation. In all these methods a joint is formed at the interface between the plastic and the fibrous material in the sense of a microscopic self-closure in that the plasticized plastics material is pressed into surface unevennesses of the fibrous material. Such methods are e.g. described in FR-2455502, FR-1495999, DE-3828340 or EP-269476. According to WO-96/01377 the plastics part can also be a dowel, which joins together two wooden parts. The same principle forms the basis for known methods for joining parts made from wood or woodlike materials, in which between the parts to be joined is placed a layer of a thermoplastics material, e.g. a paint layer and the parts are then pressed together and subject to ultrasonic action

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(JP-52127937, WO-96/01377).

In all the aforementioned methods synthetic material and fibrous material are joined together by surface adhesion resulting from microscopic self-closure and this occurs in the same way in conventional bonding or adhesion processes. The above methods have many of the same disadvantages as bonding methods, particularly their sensitivity to moisture and thermal stresses, in which the two joined together surfaces expand to varying extents and considerable shear forces arise, which weaken or even destroy the joint.

The problem of the invention is to provide a method for anchoring joining elements, e.g. joining pins, in parts made from a material having pores or cavities, particularly in parts made from wood or woodlike materials, said method being based on the aforementioned methods for joining plastic/synthetic material and wooden parts, but in which the disadvantages thereof are at least reduced, i.e. in particular provides anchorings, which are more stable under thermal and/or moisture stresses and loads. The method must be simple, but still adaptable in specific manner to joining elements with different functions and to different material types. The method must also be performable with known means and tools and at a limited cost.

This problem is solved by the method defined in the claims.

According to the method of the invention for an anchoring plasticized synthetic material is not only pressed into surface unevennesses as in the known methods, but instead into pores or cavities within the part in which the joining element is to be anchored, so that a macroscopic anchoring is formed. This macroscopic anchoring is based on the penetration of the plasticized synthetic material into microscopic pores of the material and to the formation of a type of composite comprising the original porous material and the synthetic material which has penetrated it or to macroscopic self-closure, which results from the fact that the plasticized synthetic material is pressed into macroscopic cavities.

According to the method of the invention in the part in which the joining



element is to be anchored an opening with a closed end, e.g. a bore (blind hole) is formed and then in said bore is positioned the joining element, which is wholly or partly made from a thermoplastic material.

The shapes of the bore and the joining element are so matched to one another that the joining element, without force expenditure, can be introduced into the bore up to a first position and that, if it is driven with the aid of a pressing force parallel to the bore axis from said first position towards the closed end of the bore into a second, final position, pressure builds up at at least one predetermined anchoring point between the joining element and the bore wall, whereas no pressure arises at other points.

Simultaneously with the pressing in of the joining element from its first into its second position in the bore or immediately prior thereto energy is supplied to the joining element in such a way that the plastics material is locally plasticized at the aforementioned, predetermined anchoring points, where the pressure is concentrated. Such a planned, local plasticizing can e.g. be achieved in that:

- the joining element is entirely made from a thermoplastic material or at least in areas of the predetermined anchoring points has at least surface areas made from a thermoplastic material and in that such a joining element is subject to ultrasonic or some other appropriate vibration action for the supply of energy, so that at the pressure concentration points (predetermined anchoring points) the greatest friction and therefore the maximum heat is produced and consequently the thermoplastic material is locally plasticized (related to joining methods such as ultrasonic, friction, vibration or orbital welding);
- in that the joining element, in areas of the predetermined anchoring points, has at least surface areas of a thermoplastic material, which is plasticizable at a lower temperature than the remaining materials of the joining element and in that such a joining element is heated by heat supply;
- in that the joining element, in areas of the predetermined anchoring

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points, has at least surface areas of a thermoplastic material, in which are incorporated metal particles and in that such a joining element is inductively heated.

On its inside which, in the closed bore is directed towards the closed end of the bore, the joining element has at least one first, predetermined anchoring point. On its opposite outside, i.e. on the side projecting from the bore or positioned in the bore opening, the joining element has a thickening serving as a head or a means for fixing a further part or has further anchoring points spaced from the first anchoring point towards the outside. It is also conceivable to have pin-like joining elements with several predetermined anchoring points.

Whilst the joining element is pressed in the second, final position in the bore and energy is simultaneously supplied thereto, at the predetermined anchoring points where a high pressure occurs between the joining element and the bore wall, the joining element material is plasticized and as a result of the pressure at these points is pressed into the bore wall or into pores or cavities in the material, which is adjacent to the bore, whereas it remains unchanged at other points.

To ensure that the plasticized synthetic material is pressed by the pressure produced at the anchoring points into the bore wall, it must have a porosity or openings/cavities or the bore wall must be created in such a way that as a result of the pressure formed pores or cavities are produced in which the plasticized material can be pressed. Porous materials suitable for anchorings according to the method of the invention are in particular wood or woodlike materials, but also sandstone, ceramic materials, burnt brick or concrete, etc. Cavities suitable for producing anchorings according to the invention open substantially transversely to the bore axis and are in particular found in lightweight structural components.

The attainable depth of the anchoring of a synthetic material in a porous material is dependent on its structure (e.g. for wood on the density of the wood fibres), but also on the pressure applied and the locally available plasticized material quantity. As will be shown hereinafter, in solid wood

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e.g. anchoring depths of 1 to 4 cm are readily attainable.

The desirable depth of the anchoring of the synthetic material in a porous material is dependent on the loadability of the material and can be controlled via the quantity of material to be pressed in and/or via the applied pressing force level. The shape of the anchoring can be substantially controlled by a corresponding matching of the bore shape and the joining element shape. Thus, using the method according to the invention it is possible to produce anchorings, which are specifically adapted to the character of the material (e.g. wood type, orientation of the graining or density gradient relative to the orientation of the bore, etc.) in which the anchoring is to be produced and to the function and loading to be absorbed by the joining element.

The most advantageous bore and joining element shapes for a specific application, as well as the pressing force level and the quantity of energy to be supplied to the joining element are to be established experimentally in each specific case.

The inventive method for anchoring joining elements in a part made from a porous material, particularly wood or a woodlike material, or a material having suitable cavities and different types of joining elements are described in greater detail hereinafter relative to the attached drawings, wherein show:

- Fig. 1                      A specific method variant for anchoring a joining pin with a head in one wooden part for joining two wooden parts.
- Fig. 2                      Another exemplified method variant for anchoring a joining pin in two wooden parts to be joined.
- Figs. 3 to 5                Three exemplified embodiments of the anchoring point in areas of the closed bore end.

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Fig. 6            An example of a fitting, which is fixed with the aid of a plurality of joining pins anchored in a wooden part to said part.

Fig. 7            Another exemplified method variant for anchoring a joining element, which has an internal thread for fixing further parts.

Fig. 8            An example of an anchoring according to the invention in a lightweight component with cavities.

In all the drawings the joining elements, bores and anchorings are shown in section along the bore axis.

Fig. 1 shows as the first, exemplified variant of the inventive method an anchoring of a pin-like joining element with head (joining pin 3.1) in a first, wooden part 1 for joining said first part 1 to a second part 2.1, which is e.g. also made from wood.

In the vicinity of its inner end the joining pin 3.1 has a predetermined, first anchoring point 31 and at its outer end a head 32. The bore 4.1 which passes entirely through the part 2.1 and has in part 1 a closed end 41 is less deep than the joining pin 3.1 is long and has at its open end e.g. a widened depression for countersinking the head 32. The cross-section of the bore 4.1 is so matched to the cross-section of the joining pin 3.1, that without force expenditure the pin can be introduced into the bore up to the closed end 41 thereof. This is the first position of the joining pin 3.1 in the bore 4.1.

From the first position the joining pin 3.1 is pressed further into the bore 4.1 with a pressing force  $F$  oriented substantially parallel to the bore axis. The only point at which the pressing force  $F$  gives rise to a pressure between the joining pin 3.1 and the wall of the bore 4.1 is the area of the closed bore end 41. If in the above-described manner, by supplying energy to the joining pin it is ensured that during pressing in the material of the joining pin is only plasticized at this point, only at

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this point is there an anchoring 10 of the joining pin in the part 1 to be joined.

In the drawing this anchoring 10 is shown as a synthetic material area, but in fact is constituted by an intimate mixture of wood fibres and synthetic material, which can be likened to a composite material and which can e.g. be of pinewood, whose graining is oriented parallel to the bore axis, where it has a depth of up to 2 cm.

The length of the joining pin 3.1, the depth of the bore 4.1, the force F and the quantity of energy to be supplied are so matched to one another that the anchoring fulfils the desired strength conditions and that the two parts are firmly fixed together between the joining pin head 32 and the anchoring 10.

The joining pin 3.1 of fig. 1 is anchored in the part 1 by the anchoring point 10, which is only possible in a part made from a porous material, particularly wood or a woodlike material, or, if the bore wall material has suitable cavities in the vicinity of the anchoring point or if the pressure exerted on the joining pin produces such openings in the bore wall.

Part 2.1 can also be made from wood or some other, non-porous material (metal, plastic). As shown in fig. 1, the head 32 can be a component of the joining pin. However, the head can also be placed on the joining pin after producing the anchoring, e.g. can be screwed into a thread provided in the joining pin. The head 32 can be in any random form and can e.g. also represent a fitting with a specific function.

An advantage of joining two parts in the manner shown in fig. 1 compared with other joining methods, in which plasticized materials are used as joining materials, is that in all cases it is possible to prevent plasticized material being pressed into the gap between the parts 1 and 2.1 to be joined resulting in the pressing apart thereof. This is prevented in that in the areas of such a gap no pressure is built up and the material of the joining pin is not plasticized in said area.

The bore 4.2 has a cross-sectional reduction 42 corresponding to the cross-sectional reduction on the joining pin 3.2 and on it rests the joining pin in its first position. If the joining pin 3.2 is pressed by the pressing force F more deeply into the bore 4.2, pressure builds up not only in the vicinity of the closed end 41 of the bore 4.2, but also in the area of the cross-sectional reduction 42, is pressed through the plastics material plasticized at this point into the wall of the bore 4.2 and consequently

forms a second anchoring 20.

The bores 4.1 and 4.2 of figs. 1 and 2 advantageously have a circular cross-section. The joining pins 3.1 and 3.2 can also be circular. However, they can also have some other cross-section fitting into the corresponding bore. For example, in the vicinity of its smaller cross-section, the joining pin 3.2 can be circular and in the area of its larger cross-section can have an angular cross-section (e.g. square), only the areas of the edges resting on the step 42.

In both figs. 1 and 2 the closed end 41 of the bore is shown flat and the joining pin in its first position rests with a flat face in the bore. With such a shaping of the bore and joining pin, on pressing in the pin, a substantially uniform pressure builds up over the entire face. The plasticized material is mainly driven into the wood parallel to the longitudinal axis of the joining pin, so that the cross-section of the anchoring 10 is only slightly larger than the cross-section of the joining pin.

Such a construction of the predetermined, first anchoring point is advantageous for applications in which, in the vicinity of the first anchoring 10, the wood graining is oriented parallel to the bore axis and the wood of part 1 splits in the case of a limited displacement. Roughly the same effect is obtainable with a pin end tapered to a point, which in its first position rests on a roughly identically tapering bore end.

Figs. 3 to 5 show further embodiments advantageous for specific applications of predetermined, first anchoring points 31 on e.g. pin-like joining elements 3 and cooperating, closed ends 41 of bores 4, which particularly in the case of ultrasonic application leads to different anchorings 10.

Fig. 3 shows in two variants one end of a joining pin 3, which is placed in a closed end of a bore 4. In both cases the pin end is pointed and specifically more sharply than the bore end. As a result the pressure arising on pressing the joining pin 3 into the bore 4 is centrally concentrated, so that the material is to an even greater extent pressed parallel to the pin axis into the part 1, so that also here the resulting anchoring

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10 extends more in the axial direction than at right angles thereto. The strength of such an anchoring is more particularly due to an enlargement of the shear-loaded surfaces in the wood.

Fig. 4 shows one end of a pin 3 having a concave shape. On pressing this pin into a bore with a flat or pointed, closed end, the pressure mainly builds up at radial positions, which gives rise to an anchoring 10, which extends to a greater extent transversely to the pin axis. Such an anchoring is more particularly suitable for a part 1, where the graining is at right angles to the pin axis, or for an anchoring in a chipboard, whose surface is at right angles to the pin axis. The strength of such an anchoring results more particularly from the self-closure obtained between the wooden part and the joining pin.

Fig. 5 shows another embodiment of the predetermined, first anchoring point 31 on a joining pin 3 and a corresponding bore end 41. It is a first anchoring point having substantially the same construction as the second anchoring point of fig. 2. Bore 4 has a step-like cross-sectional reduction 43, on which is mounted the pin in its first position. If this joining pin is pressed into the bore, more particularly a pressure is built up radially in the vicinity of the bore end and the plasticized material is pressed into the wood, more particularly transversely to the pin axis.

Fig. 6 shows a part 5 made from a random material, which is fixed to a part 1 with the aid of pin-like joining elements 3, which are anchored in said part 1 e.g. made from wood and in accordance with the method of the invention. The part 5 is a fitting (e.g. a hinge part), e.g. made from plastic. The two joining pins 3 are shaped onto the part 5 or are joined thereto in some other appropriate way and are driven in the described way into bores of part 1 and anchored therein. Here again, as mentioned in conjunction with fig. 1 concerning a joining pin head, the part 5 can have a random shape and, even after producing the anchoring, can be appropriately mounted on the joining pin or pins 3.

Fig. 7 shows the production of a connection of a wooden part 1 with a fitting part 6, e.g. made from metal, by means of an inventive anchoring of

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a joining element 3.3 in part 1 and the fixing of the fitting part 6 to the anchored joining element 3.3. The joining element 3.3 has a two-step, first anchoring point 31 and is introduced into a bore 4.3 with a step-like, narrowing base. On pressing the joining element into the bore and during the simultaneous plasticizing of the anchoring point 31, bore 4.3 and joining element 3.3 act as explained in conjunction with fig. 4. A corresponding "two-step" anchoring 10 is formed.

The joining element 3.3 of fig. 7 has at its outside, facing the predetermined anchoring point, as the means for fixing a further part an internal thread 34, into which is screwed the fitting part 6 after anchoring the joining element 3.3 in part 1.

Fig. 8 shows the result of a further, exemplified embodiment of the inventive method, namely an anchoring of a joining element 3.4 in a part 1, which is a lightweight constructional component with cavities 11. The closed bore necessary for the method according to the invention and into which is introduced the joining element 3.4, is in this case a through bore 4.4 through one of the outer layers 1.1 of part 1. This through bore 4.4 is closed by a further element, e.g. by an inner layer 1.2 or optionally by the facing, outer layer 1.3, in such a way that between the through bore 4.4 and the element closing it opens a cavity area 11.1 extending substantially at right angles to the bore axis or is produced by the pressure of the joining element 3.4 on the bore-closing element, e.g. by a corresponding deformation of the inner layer 1.2.

The joining element 3.4 is inserted in the bore 4.4 and is positioned by the bore-closing element (e.g. inner layer 1.2). The joining element 3.4 is then pressed against the bore-closing element and simultaneously the plastics material is plasticized in the area of this element and is pressed into the cavity area 11.1, existing or produced between the outer layer 1.1 and the bore-closing element, so that a macroscopic anchoring 10 is obtained.

As has been stated, the method according to fig. 8 is particularly suitable for lightweight constructional applications where, in place of solid

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material, use is made of thin, board-like material carried by a support structure (indicated by the two laths 20). The outer layers 1.1 and 1.3 are e.g. thin solid wood boards or coated chipboards. The element closing the bore 4.4 can e.g. be a plastic or metal inner layer 1.2 extending from a lath 20 to a neighbouring lath 20 or over the entire surface of the first layer, or can be a differently shaped element locally and specifically integrated for this purpose into the cavity 11.

The joining element 3.4 according to fig. 8 is e.g. suitable for fixing fittings to lightweight structural components.

Thermoplastic materials for use in joining elements advantageously have a high mechanical strength, particularly a high tensile strength and a high modulus of elasticity. Polyamides, polycarbonates or polyester carbonates are particularly suitable. For increasing the strength the plastics material of a joining element can e.g. also contain glass or carbon fibres. Further thermoplastics suitable for joining elements are acrylonitrile-butadiene-styrene, styrene-acrylonitrile, polymethylmethacrylate, polyvinyl chloride, polyethylene, polypropylene and polystyrene.

An exemplified joining pin for joining two wooden parts, as shown in fig. 2, e.g. has the form shown in fig. 2 and is made entirely from acrylonitrile-butadiene-styrene. It has a smaller, circular cross-section with a diameter of 8 mm and a larger, circular cross-section with a diameter of 10 mm. It is 60 mm long and is centrally provided with the cross-sectional reduction. The corresponding bore is 40 mm deep and has the step corresponding to the cross-sectional reduction of the pin at a height of 30 mm. The pin is inserted in the bore and is pressed into it for 5 sec. with a pressing force of 2000N and ultrasonic excitation with an amplitude of approximately 44  $\mu$ m. Subsequently the pin end is flush with the wood surface.

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METHOD FOR ANCHORING JOINING ELEMENTS IN A MATERIAL HAVING PORES OR

CAVITIES, AS WELL AS JOINING ELEMENTS FOR ANCHORING

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FIELD OF THE INVENTION

The invention relates to a method ~~according to the preamble of claim 1.~~  
~~The method is used for~~ anchoring joining elements in a material having pores or cavities, particularly in wood or woodlike materials (e.g. chipboards). The invention also relates to joining elements for use in the method. The joining elements anchored according to the method of the invention are more particularly used for producing constructions <sup>comprising</sup> ~~consti-~~ <sup>attaching</sup> ~~tuted by~~ different parts or for ~~fixing~~ fittings.

BACKGROUND OF THE INVENTION

According to the prior art, parts made from wood or woody materials are interconnected, e.g., using joining elements in the form of nails or screws, <sup>which</sup> ~~in that they~~ are driven through one of the parts to be joined into the other part to be joined. Screws and nails are generally made from metal and have <sup>a head</sup> ~~in a~~ surface area of one of the parts to be joined ~~a head~~ and are at least frictionally or positively anchored in another of the parts to be joined. These pin-like joining elements constitute in wooden structures metallic, often corrosive, foreign bodies <sup>which</sup> can be prejudicial to working after the joining of the parts and which represent heat transfer bridges in the finished structures.

It is also known to join parts made from fibrous materials, including wood and woodlike materials, to parts made from thermoplastics. ~~in that~~ The thermoplastic is plasticized at its surface facing the fibrous material part and the two surfaces are pressed onto one another. The plastic is thereby applied in plasticized form to the surface of the fibrous material or it is plasticized in the final position, e.g., by ultrasonic excitation. In all <sup>of</sup> these methods, a joint is formed at the interface between the plastic and the fibrous material in the sense of a microscopic <sup>interlocking</sup> ~~self-closure~~ in that the plasticized plastics material is pressed into surface <sup>irregularities</sup> ~~unevennesses~~ of the fibrous material. Such methods are, e.g., described in FR-2455502, FR-1495999, DE-3828340 or EP-269476. According to WO-96/01377, the plastics part can also be a dowel, which joins together two wooden parts. The same principle forms the basis for known methods for joining parts made from wood or woodlike materials, in which between the parts to be joined is placed a layer of a thermoplastics material, e.g., a paint layer, and the parts are then pressed together and subject <sup>ed</sup> to ultrasonic action

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(JP-52127937, WO-96/01377).

In all the aforementioned methods, synthetic material and fibrous material are joined together by surface adhesion resulting from microscopic ~~self~~<sup>interlocking</sup> closure and this occurs in the same way in conventional bonding or adhesion processes. The above methods have many of the same disadvantages as bonding methods, particularly their sensitivity to moisture and thermal stresses in which the two joined-together surfaces expand to varying ~~degrees~~<sup>degrees</sup> and considerable shear forces arise which weaken or even destroy the joint.

*An object* SUMMARY OF THE INVENTION <sup>present</sup>  
The ~~problem~~ of the invention is to provide a method for anchoring joining elements, e.g., joining pins, in parts made from a material having pores or cavities, particularly in parts made from wood or woodlike materials, ~~and~~<sup>this</sup> method being based on the aforementioned methods for joining plastic/synthetic material and wooden parts, but in which the disadvantages thereof are at least reduced, i.e., in particular provides anchoring<sup>s</sup>, which are more stable under thermal and/or moisture stresses and loads. The method ~~must be~~<sup>is</sup> simple, but still adaptable in specific ~~manner~~<sup>ways</sup> to joining elements with different functions and to different material types. The method ~~must~~<sup>is</sup> also ~~be~~ performable with known means and tools and at a limited cost.

~~This problem is solved by the method defined in the claims.~~

According to the method of the invention, ~~for~~<sup>merely</sup> an anchoring plasticized synthetic material is not ~~only~~<sup>irregularities</sup> pressed into surface ~~unevennesses~~ as in the known methods, but instead into pores or cavities within the part in which the joining element is to be anchored, so that a macroscopic anchoring is formed. This macroscopic anchoring is based on the penetration of the plasticized synthetic material into microscopic pores of the material and to the formation of a type of composite comprising the original porous material and the synthetic material which has penetrated it or to macroscopic ~~self-closure~~<sup>interlocking</sup>, which results from the fact that the plasticized synthetic material is pressed into macroscopic cavities.

According to the method of the invention ~~in the part~~ in which the joining

element is to be anchored, an opening with a closed end, e.g., a bore (blind hole) is formed and then ~~in said bore is positioned~~ the joining element *the joining element being which is, wholly or partly made from a thermoplastic material.* *is positioned in the bore,*

The shapes of the bore and the joining element are so matched to one another that the joining element, without force expenditure, can be introduced into the bore up to a first position and that, if it is driven with the aid of a pressing force parallel to the bore axis from ~~said~~ *the* first position towards *y* the closed end of the bore into a second, final position, pressure builds up at at least one predetermined anchoring point between the joining element and the bore wall, ~~whereas~~ *but* no pressure arises at other points.

Simultaneously with the pressing in of the joining element from its first ~~into~~ its second position in the bore, or immediately prior thereto, energy is supplied to the joining element in such a way that the plastics material is locally plasticized at the aforementioned, predetermined anchoring points *y* where the pressure is concentrated. ~~Such a~~ *This* planned, local plasticizing can, e.g., be achieved *by providing at least one of the following characteristics:*

- the joining element is entirely made from a thermoplastic material or at least in areas of the predetermined anchoring points has at least surface areas made from a thermoplastic material and ~~in that such a~~ *the* joining element is subject *y* to ultrasonic or some other appropriate vibration action for ~~the~~ *supplying* of energy, so that at the pressure concentration points (predetermined anchoring points) the greatest friction and therefore the maximum heat is produced and consequently the thermoplastic material is locally plasticized (related to joining methods such as ultrasonic, friction, vibration or orbital welding);
- ~~in that~~ the joining element, in areas of the predetermined anchoring points, has at least surface areas of a thermoplastic material *y* which ~~is~~ *are* plasticizable at a lower temperature than the remaining materials of the joining element and in that ~~such a~~ *the* joining element is heated by heat supply;
- ~~in that~~ the joining element, in areas of the predetermined anchoring

In the <sup>of the joining element</sup> ~~On its~~ inside, which, in the closed bore, is directed towards the closed end of the bore, the joining element has at least one first, predetermined anchoring point. On its opposite outside, i.e., on the side projecting from the bore or positioned in the bore opening, the joining element has a thickening serving as a head or a means for <sup>attaching</sup> ~~fixing~~ a further part or has further anchoring points <sup>toward the outside</sup> spaced from the first anchoring point, ~~towards the~~ <sup>outside</sup>. It is also conceivable to have pin-like joining elements with several predetermined anchoring points.

To, <sup>be</sup> ensure that the plasticized synthetic material is pressed by the pressure produced at the anchoring points into the bore wall, <sup>the bore wall</sup> it must ~~have a~~ <sup>be</sup> porous <sup>have</sup> or openings <sup>or</sup> cavities, or the bore wall must be created in such a way that, as a result of the pressure, formed pores or cavities are produced <sup>into</sup> in which the plasticized material can be pressed. Porous materials suitable for anchoring <sup>s</sup> according to the method of the invention are in particular wood or woodlike materials, but also sandstone, ceramic materials, burnt brick or concrete, etc. Cavities suitable for producing anchoring <sup>s</sup> according to the invention open substantially transversely to the bore axis and are in particular found in lightweight structural components.

The attainable depth of the anchoring of a synthetic material in a porous material is dependent on its structure (e.g. for wood on the density of the wood fibres), but also on the pressure applied and the locally available plasticized material quantity. As will be shown hereinafter, in solid wood

e.g., anchoring depths of 1 to 4 cm are readily attainable.

The desirable depth of the anchoring of the synthetic material in a porous material is dependent on the loadability of the material and can be controlled <sup>by</sup> ~~via~~ the quantity of material to be pressed in and/or <sup>by</sup> ~~via~~ the applied pressing force level. The shape of the anchoring can be substantially controlled by a <sup>suitable</sup> ~~corresponding~~ matching of the bore shape and the joining element shape. Thus, using the method according to the invention it is possible to produce anchorings<sup>s</sup>, which are specifically adapted to the character of the material (e.g., wood type, orientation of the graining or density gradient relative to the orientation of the bore, etc.) in which the anchoring is to be <sup>accomplished</sup> ~~produced~~ and to the function and loading to be absorbed by the joining element.

The most advantageous bore and joining element shapes for a specific application, as well as the pressing force level and the quantity of energy to be supplied to the joining element are to be established experimentally in each specific case.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The inventive method for anchoring joining elements in a part made from a porous material, particularly wood or a woodlike material, or a material having suitable cavities and different types of joining elements, <sup>is</sup> ~~are~~ described in greater detail hereinafter <sup>with reference</sup> ~~relative~~ to the attached drawings, wherein ~~show~~:

Fig. 1 <sup>is a diagram showing successive steps in one embodiment of a</sup> ~~is a diagram of a specific method variant~~ for anchoring a joining pin with a head in one wooden part for joining two wooden parts;

Fig. 2 <sup>showing successive steps in another embodiment of a</sup> ~~is a diagram of another exemplified method variant~~ for anchoring a joining pin in two wooden parts to be joined;

Figs. 3, <sup>4 and</sup> ~~to 5 are~~ <sup>diagrams showing steps of forming three</sup> ~~Three exemplified~~ embodiments of the anchoring point in areas of the closed bore end;

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Fig. 6 is a side <sup>elevation</sup> ~~An example~~ of a fitting, which is <sup>attached to a wooden part using</sup> ~~fixed with the aid of a~~ plurality of joining pins anchored in <sup>the</sup> ~~a~~ wooden part. ~~to said~~ part.

Fig. 7 is a <sup>sectional side elevation of a</sup> ~~Another exemplified~~ method ~~variant~~ for anchoring a joining element <sup>which</sup> has an internal thread for <sup>attaching</sup> ~~fixing~~ further parts; and

Fig. 8 is a <sup>sectional side elevation</sup> ~~An example~~ of an anchoring according to the invention <sup>anchored</sup> in a lightweight component with cavities.

<sup>of</sup> In all, the drawings, the joining elements, bores and anchorings <sup>S</sup> are shown in section along the bore axis.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS <sup>embodiment</sup>  
Fig. 1 shows <sup>as</sup> ~~the first, exemplified variant~~ of the inventive method <sup>which involves</sup> an anchoring of a pin-like joining element <sup>31</sup> with <sup>a</sup> head <sup>32</sup> ~~(joining pin 3.1)~~ in a first, wooden part 1 for joining ~~said~~ first part 1 to a second part 2.1, which is, e.g., also made from wood.

In the vicinity of its inner end, ~~the~~ joining pin 3.1 has a predetermined, first anchoring point 31 and at its outer end <sup>has</sup> a head 32. ~~The~~ Bore 4.1 <sup>which</sup> passes entirely through ~~the~~ part 2.1 and has, in part 1, a closed end <sup>the total length of bore 4.1 being</sup> 41, <sup>length of</sup> ~~is~~ less deep than the <sup>length of</sup> joining pin 3.1. ~~is long and has~~ At <sup>the</sup> its open end of bore 4.1, e.g., a widened depression for countersinking ~~the~~ head 32. The cross-section of ~~the~~ bore 4.1 is so matched to the cross-section of the joining pin ~~that~~ <sup>that</sup>, without force expenditure, the pin can be introduced into the bore up to ~~the~~ closed end 41 thereof. This is the first position of ~~the~~ joining pin 3.1 in ~~the~~ bore 4.1.

From the first position, ~~the~~ joining pin 3.1 is pressed further into ~~the~~ bore 4.1 with a pressing force F oriented substantially parallel to the bore axis. The only point at which the pressing force F gives rise to ~~a~~ pressure between ~~the~~ joining pin 3.1 and the wall of the bore 4.1 is the area of ~~the~~ closed bore end 41. If, in the above-described manner, by supplying energy to the joining pin it is ensured that during pressing in the material of the joining pin is only plasticized at this point, only at

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this point is there ~~an~~ anchoring 10 of the joining pin in the part 1 to be joined.

In the drawing, <sup>location</sup> this anchoring 10 is shown as a synthetic material area, but in fact is constituted by an intimate mixture of wood fibres and synthetic material, which can be likened to a composite material and which can, e.g., be of pinewood, whose graining is oriented parallel to the bore axis, where it has a depth of up to 2 cm.

The length of ~~the~~ joining pin 3.1, the depth of ~~the~~ bore 4.1, the <sup>magnitude of</sup> force F and the quantity of energy to be supplied are so matched to one another that the anchoring fulfils the desired strength conditions and that the two parts are firmly fixed together between the joining pin head 32 and the anchoring 10.

The joining pin 3.1 of Fig. 1 is anchored in the part 1 by the anchoring point 10, which is only possible in a part made from a porous material, particularly wood or a woodlike material, or, if the bore wall material has suitable cavities in the vicinity of the anchoring point or if the pressure exerted on the joining pin produces such openings in the bore wall.

Part 2.1 can also be made from wood or some other, non-porous material (metal, plastic). As shown in Fig. 1, the head 32 can be a component of the joining pin. However, the head can also be placed on the joining pin after producing the anchoring, e.g., can be screwed into a thread provided in the joining pin. The head 32 can be in any random form and can, e.g., also represent a fitting with a specific function.

An advantage of joining two parts in the manner shown in Fig. 1 compared with other joining methods, in which plasticized materials are used as joining materials, is that in all cases it is possible to prevent plasticized material being pressed into the gap between the parts 1 and 2.1 to be joined, resulting in the pressing apart thereof. This is prevented <sup>by the feature</sup> ~~in that~~, in the <sup>region</sup> ~~area~~ of such a gap, no pressure is built up and the material of the joining pin is not plasticized in <sup>that region</sup> ~~said area~~.

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If the energy to be supplied to the joining pin 3.1 is supplied in the form of heat, in the vicinity of the anchoring point it is constituted by a plastics material which is plasticizable at a lower temperature than the material from which the joining pin is made in other areas. It is also conceivable in such a case for the joining pin to have a "core" of a heat conducting material, e.g., metal, by means of which core the heat to be supplied to the joining pin can be conducted <sup>toward</sup> ~~against~~ the anchoring point.

Fig. 2 shows ~~as~~ <sup>embodiment</sup> a further ~~exemplified variant~~ <sup>using an</sup> of the inventive method ~~an~~ anchoring of a pin-like joining element (joining pin 3.2) in two parts 1 and 2.2 to be joined together and which are, e.g., of wood, ~~the~~ joining pin 3.2 being anchored in both parts 1 and 2.2 (anchoring <sup>points</sup> 10 and 20).

The Bore 4.2 has a cross-sectional reduction 42 corresponding to the cross-sectional reduction on the joining pin 3.2 and on it rests the joining pin in its first position. If the joining pin 3.2 is pressed by the pressing force F more deeply into the bore 4.2, pressure builds up not only in the vicinity of the closed end 41 of the bore 4.2, but also in the area of the cross-sectional reduction 42, is pressed through the plastics material plasticized at this point into the wall of the bore 4.2 and consequently

forms a second anchoring <sup>point</sup> 20.

The bores 4.1 and 4.2 of Figs. 1 and 2 advantageously have a circular cross-section. The joining pins 3.1 and 3.2 can also be circular. However, they can also have some other cross-section fitting into the corresponding bore. For example, in the vicinity of its smaller cross-section, the joining pin 3.2 can be circular and in the area of its larger cross-section can have <sup>an</sup> angular cross-section (e.g. square) <sup>with</sup> only the areas of the edges resting on the step 42.

In both Figs. 1 and 2 the closed end 41 of the bore is shown flat and the joining pin in its first position rests with a flat face in the bore. With such a shaping of the bore and joining pin, on pressing in the pin, a substantially uniform pressure builds up over the entire face. The plasticized material is mainly driven into the wood parallel to the longitudinal axis of the joining pin, so that the cross-section of the anchoring 10 is only slightly larger than the cross-section of the joining pin.

Such a construction of the predetermined, first anchoring point is advantageous for applications in which, in the vicinity of the first anchoring 10, the wood graining is oriented parallel to the bore axis and the wood of part 1 splits in the case of a limited displacement. Roughly the same effect is obtainable with a pin end tapered to a point, which in its first position rests on a roughly identically tapering bore end.

Figs. 3 to 5 show further embodiments advantageous for specific applications of predetermined, first anchoring points 31 on, e.g., pin-like joining elements 3 and cooperating, closed ends 41 of bores 4, which particularly in the case of ultrasonic application, leads to different anchoring <sup>points</sup> 10.

Fig. 3 shows <sup>embodiments of inner</sup> two ~~variants~~ <sup>embodiments of inner</sup> ends of a joining pin 3, which is placed in a closed end of a bore 4. In both cases, the pin end is pointed, and specifically more sharply than the bore end. As a result the pressure arising <sup>when</sup> pressing the joining pin 3 into the bore 4 is centrally concentrated, so that the material is, to an even greater extent, pressed parallel to the pin axis into the part 1, so that also here the resulting anchoring ~~point~~ <sup>point</sup>

10 extends more in the axial direction than at right angles thereto. The strength of such an anchoring is more particularly due to an enlargement of the shear-loaded surfaces in the wood.

Fig. 4 shows one end of a pin 3 having a concave shape. <sup>When</sup> ~~On~~ pressing this pin into a bore with a flat or pointed, closed end, the pressure mainly builds up at radial positions, which gives rise to an anchoring 10, which extends to a greater extent transversely to the pin axis. Such an anchoring is more particularly suitable for a part 1 <sup>y</sup> where the graining is at right angles to the pin axis, or for an anchoring in a chipboard, whose surface is at right angles to the pin axis. The strength of such an anchoring results more particularly from the <sup>interlocking</sup> ~~self-closure~~ obtained between the wooden part and the joining pin.

Fig. 5 shows another embodiment of the predetermined, first anchoring point 31 on a joining pin 3 and a corresponding bore end 41. It is a first anchoring point having substantially the same construction as the second anchoring point of Fig. 2. Bore 4 has a step-like cross-sectional reduction 43, on which is mounted the pin in its first position. <sup>When</sup> ~~If~~ this joining pin is pressed into the bore, more particularly a pressure is built up radially in the vicinity of the bore end and the plasticized material is pressed into the wood <sup>y</sup> more particularly transversely to the pin axis.

Fig. 6 shows a part 5 made from a random material, which is fixed to a part 1 <sup>using</sup> ~~with the aid of~~ pin-like joining elements 3 <sup>y</sup> which are anchored in ~~said~~ <sup>which is,</sup> part 1, e.g., made from wood and in accordance with the method of the invention. ~~The~~ Part 5 is a fitting (e.g. a hinge part), e.g., made from plastic. ~~The~~ <sup>formed</sup> two joining pins 3 are ~~shaped~~ <sup>formed</sup> onto the part 5 or are joined thereto in some other appropriate way and are driven in the described way into bores of part 1 and anchored therein. Here again, as mentioned in conjunction with Fig. 1 concerning a joining pin head, ~~the~~ part 5 can have a random shape and, even after producing the anchoring, can be appropriately mounted on ~~the~~ joining pin or pins 3.

Fig. 7 shows the production of a connection of a wooden part 1 with a fitting part 6, e.g., made from metal, by means of an inventive anchoring of

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a joining element 3.3 in part 1 and the <sup>attachment</sup> ~~fixing~~ of the fitting part 6 to the anchored joining element 3.3. The joining element 3.3 has a two-step, first anchoring point 31 and is introduced into a bore 4.3 with a step-like, narrowing base. On pressing the joining element into the bore and during the simultaneous plasticizing of the anchoring point 31, bore 4.3 and joining element 3.3 act as explained in conjunction with ~~fig.~~ <sup>mating</sup> fig. 4. A ~~corres-~~ <sup>ponding</sup> "two-step" anchoring 10 is formed.

The joining element 3.3 of Fig. 7 has at its outside, facing the predetermined anchoring point, as the means for fixing a further part, an internal thread 34, into which is screwed the fitting part 6 after anchoring the joining element 3.3 in part 1.

Fig. 8 shows the result of a further, ~~exemplified~~ embodiment of the inventive method, namely an anchoring of a joining element 3.4 in a part 1, which is a lightweight constructional component with cavities 11. The closed bore necessary for the method according to the invention and into which is introduced the joining element 3.4 is in this case a through-bore 4.4 through one of the outer layers 1.1 of part 1. This through-bore 4.4 is closed by a further element, e.g., by an inner layer 1.2 or optionally by the facing, outer layer 1.3, in such a way that between the through-bore 4.4 and the element closing it opens a cavity area 11.1 extending substantially at right angles to the bore axis or is produced by the pressure of the joining element 3.4 on the bore-closing element, e.g., by a corresponding deformation of the inner layer 1.2.

The joining element 3.4 is inserted in the bore 4.4 and is positioned by the bore-closing element (e.g. inner layer 1.2). The joining element 3.4 is then pressed against the bore-closing element and simultaneously the plastics material is plasticized in the area of this element and is pressed into the cavity area 11.1, existing or produced between the outer layer 1.1 and the bore-closing element, so that a macroscopic anchoring 10 is obtained.

As has been stated, the method according to Fig. 8 is particularly suitable for lightweight constructional applications where, in place of solid

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material, use is made of thin, board-like material carried by a support structure (indicated by the two laths 20). The outer layers 1.1 and 1.3 are, e.g., thin solid wood boards or coated chipboards. The element closing the bore 4.4 can, e.g., be a plastic or metal inner layer 1.2 extending from a lath 20 to a neighboring lath 20 or over the entire surface of the first layer, or can be a differently shaped element locally and specifically integrated for this purpose into the cavity 11.

The joining element 3.4 according to Fig. 8 is, e.g., suitable for <sup>attaching</sup> ~~fixing~~ fittings to lightweight structural components.

Thermoplastic materials for use in joining elements advantageously have a high mechanical strength, particularly a high tensile strength and a high modulus of elasticity. Polyamides, polycarbonates or polyester carbonates are particularly suitable. For increasing the strength, the plastics material of a joining element can, e.g., also contain glass or carbon fibres. Further thermoplastics, <sup>materials</sup> suitable for <sup>use as</sup> joining elements are acrylonitrile-butadiene-styrene, styrene-acrylonitrile, polymethylmethacrylate, polyvinyl chloride, polyethylene, polypropylene and polystyrene.

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An exemplified <sup>A</sup> joining pin for joining two wooden parts, as shown in Fig. 2, e.g., has the form shown in Fig. 2 and is made entirely from acrylonitrile-butadiene-styrene. It has a smaller <sup>portion with a</sup> circular cross-section with a diameter of 8 mm and a larger <sup>portion having a</sup> circular cross-section with a diameter of 10 mm. It is 60 mm long and is centrally provided with the cross-sectional reduction. The <sup>mating</sup> corresponding bore is 40 mm deep and has the step <sup>positioned to</sup> corresponding to the cross-sectional reduction of the pin at a height of 30 mm. The pin is inserted in the bore and is pressed into it for 5 sec. with a pressing force of 2000N and ultrasonic excitation with an amplitude of approximately 44  $\mu$ m. <sup>Upon completion of the assembly,</sup> ~~Subsequently~~ the <sup>outer</sup> pin end is flush with the wood surface.

ABSTRACT OF THE DISCLOSURE

A joining pin (3.2) with which ~~e.g. are to be joined together~~ two parts (1 and 2) made from a porous material, particularly wood or a woodlike material, <sup>are to be joined together,</sup> is anchored in the porous material at predetermined anchoring points (31, 33). For this purpose, a bore (4.2) with a closed <sup>inner</sup> end (41) is made in the parts (1 and 2). The shape of this bore (4.2) is so matched to the joining pin (3.2) that it can be introduced substantially without force expenditure into the bore and is positionable in a first position, ~~and that~~ <sup>at</sup> at least one predetermined anchoring point (31, 33) between the joining pin (3.2) and the wall of the bore (4.2) <sup>is formed when</sup> pressure is built up <sup>by pressing</sup> ~~if~~ the joining pin (3.2) ~~is pressed~~ with a pressing force (F) more deeply into the bore <sup>to</sup> ~~in~~ a second position. Energy is supplied in <sup>a</sup> planned manner to the joining pin (3.2) <sup>so</sup> so that at the predetermined anchoring points (31, 33) the thermoplastic material of the joining pin (3.2) is plasticized. The locally plasticized plastic material is pressed by the local pressure into the porous material of the parts and forms local, macroscopic anchoring <sup>s</sup> ~~inge~~ (10, 20). The joining pin (3.2) is, e.g., made entirely from a thermoplastic material and the energy for plasticizing is supplied thereto by ultrasonic vibration.

(Fig. 2)

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